

be available on which to trace changes. The present distribution of contributing stations, India, western Europe, and America, fulfils in some sort this need, though a distinct lacuna exists in the longitude of Australia.

A paper, by Prof. Hale, on the measurement of spectroheliograms gave rise to an interesting discussion concerning the methods of reducing the photographs already obtained. In his case, after some experiments, a photometric method of determining the areas of selected flocculi had given satisfactory accord, while Sir Norman Lockyer was able to report that, in the direct measurement of the series of spectroheliograms being formed at South Kensington, and in spite of the difficulties, good agreement was obtained by the two observers engaged in the work. In the study of the relation between solar activities and terrestrial changes, measurements of the numbers and areas of flocculi are likely to be of great importance. At all times the areas affected are greatly in excess of the spotted areas, while during the almost spotless periods of sun-spot minima, flocculi persist (in lessened degree), and bridge what would be otherwise practically a gap in the records.

The computing bureau of the union, established at Oxford under Prof. Turner, will make special studies of such spectroheliograph negatives as are entrusted to it by members: this, however, without prejudice to the right of reducing and studying photographs by those responsible for their taking. A start has already been made at Oxford on some plates lent by Prof. Hale.

The difficulties in the selection of the flocculi, recorded on the plates, for measurement, together with differences in size and quality of the photographs, make satisfactory and comparable measures far from easy. Great credit is due to the institutions and workers on this subject for the progress already made.

A proposition by Sir Norman Lockyer supporting the project for the establishment of a solar physics observatory in Australia was carried unanimously. This project, if carried into effect, would add another link to the chain of spectroheliographs girdling the earth.

An account, by M. Deslandres, of the spectroheliograph equipment and work accomplished with it at Meudon, together with an excellent picture of the sun in K_2 light, and a series of spectra in the neighbourhood of K used for the determination of the radial velocities involved in the solar activities, concludes the volume.

The delegates were invited by Prof. Hale to come to California for the next meeting, so that the date 1910 and the place Mount Wilson were provisionally decided upon, Prof. Hale being thanked for his kind invitation.

The publishers are to be congratulated on the get-up of the book, the paper and printing being good and the binding neat and effective.

T. F. C.

THE MANUFACTURE OF BASIC STEEL.

OF the many varieties of cast- or pig-iron, the three following percentage compositions may be taken as representing three most important types:—

	(a)	(b)	(c)
Carbon ...	3.5	3.5	3.5
Silicon ...	2.5	1.0	2.5
Manganese ...	0.5	2.0	0.6
Sulphur ...	0.05	0.06	0.04
Phosphorus ...	0.05	2.0	1.6

An average chemical specification with regard to sulphur and phosphorus in steel is "not to exceed

0.06 per cent. of each." For certain Government work the standard is 0.04, and easier specifications allow of 0.08, but 0.06 is a fair average.

The first pig (a) is suitable for conversion into steel by the acid process, in which the oxidising agent, whether oxygen of the air or oxygen from oxide of iron, acts upon the metal while it is contained in a vessel or a hearth composed mainly of the acid material silica. In this process the slag is necessarily of an acid nature, and sulphur and phosphorus therefore are not eliminated. Enormous quantities of iron ore are available, which contain very much higher proportions of phosphate than the hæmatite from which the cast iron of the (a) variety is produced, and as in the blast furnace practically all the phosphorus in the charge of ore, fuel, and flux enters into the metal, pig-irons are made that are much too high in phosphorus for conversion into steel by the acid process. By using a vessel or a hearth lined with basic material, such as burnt dolomite or magnesia, the steel can be finished in contact with a slag sufficiently basic to effect the removal of the phosphorus. The basic process as commonly worked some years ago, and sometimes even to-day, consisted in charging a mixture of about equal parts of pig-iron and scrap on a basic hearth, and then, by additions of iron ore and lime, eliminating the silicon and manganese, as well as the carbon and the phosphorus, to the extent necessary in the manufacture of mild steel. By this ordinary method of working, as the phosphorus is only sufficiently eliminated when the carbon is low, the process was generally used for the manufacture of mild steels, as unless the highly phosphoric slag is removed from the surface of the metal at the end, during re-carburisation phosphorus is reduced from the slag, resulting in an increased percentage of phosphorus in the bath. Sulphur is not to any great extent removed during the process as ordinarily conducted, and although the amount of sulphur in the bath can be reduced by additions of fluor-spar during the conduct of the process, these additions, if in excess, not only prove destructive to the banks of the basin-shaped receptacle, but render the phosphate in the slag insoluble, and thus decrease its value for agricultural purposes.

The pig-iron for the basic process must therefore be comparatively low in sulphur for successful regular working, and if by any means it should be high in sulphur must be subjected to a desulphurising process, such as the Massenez manganese process or the Saniter oxychloride or fluoride process.

The ordinary conditions for the manufacture in the blast furnace of pig-iron high in silicon content are those favourable to the production of a pig-iron low in sulphur, but a high-silicon pig-iron used in the ordinary basic process is again destructive to the banks of the furnace. The manufacture of a low-silicon low-sulphur pig, such as (b), can be effected by the use of manganiferous ores added to the blast-furnace charge. These ores are expensive, and the manganese in the pig-iron is lost during the conversion of the pig into steel. These statements give shortly the conditions connected with the manufacture of basic steel.

Many attempts have been made to improve the ordinary method of working, either from the point of view of being able to accept pig-iron high in sulphur, or, on the other hand, of being able to use a pig-iron high in silicon, because of the difficulty and expense connected with making the pig low in silicon and sulphur.

In 1894 a patent was granted to Messrs. Bertrand and Thiel for removing the silicon, the bulk of the phosphorus, and part of the carbon and manganese in

one basic furnace and then transferring the metal, but not the slag, to a second furnace, completing the purification and finishing the steel in the second furnace. The slag of the primary furnace is valuable, and the removal of the phosphorus before the carbon is a great advantage. This process has met with considerable success. In 1898 Talbot introduced his continuous process, which is so well known that it need hardly be described.

In 1900 Monell patented a process which has come into considerable public prominence owing to a recently decided law case with regard to its alleged infringement. In certain circumstances the amount of scrap required for the ordinary working of the basic open-hearth process is not easily obtained, and although by the ordinary process an all-pig charge may be successfully worked, the time occupied in getting rid of the large quantity of impurities increases the length of time necessary for purification, and hence decreases the output of a furnace of a given size. Monell charges on to the bottom of the open-hearth the usual quantity of limestone which was employed in a furnace of like capacity with charges of half pig and half scrap. But along with this limestone he charges an amount of oxide of iron, generally in the form of iron ore, equal to about 20 per cent. of the weight of the pig-iron it is proposed to treat. These materials are heated to a red heat, and whilst still unfused the charge of pig-iron in the molten condition, either direct from the blast furnace or from a metal mixer, is poured into the furnace as rapidly as possible. This causes an active reaction, and the materials being at a comparatively low temperature the ore oxidises the phosphorus, silicon, and manganese in the pig-iron with extreme rapidity, and at the same time oxidises a portion of the carbon.

If the phosphorus in the original pig be not more than 0.80 per cent., in about one hour it will be reduced to less than 0.1 per cent., the carbon remaining being about 2 per cent. Eighty per cent. of the slag is now removed, leaving the metal only very thinly covered, and then oxide of iron is added to the bath and the carbon gradually reduced to the percentage required; so that by this means, in the basic furnace, a steel sufficiently low in sulphur and phosphorus is produced, and of any carbon desired, without the necessity of going down to a very low percentage of carbon, as in the ordinary process, and either being content to make only mild steel or to make special arrangements for carburising after removal of the slag (the Darby process). The yield by the Monell process is more than 100 per cent. of the metallic charge, owing to reduction of iron from the ore, the mean of about eighty consecutive trial heats being 108 per cent., but this is a feature not peculiar to this modification only. Unfortunately for the usefulness of the Monell process in this country, when the pig-iron contains from 1.5 per cent. to 2.0 per cent. phosphorus, as only about 80 to 90 per cent. of the total phosphorus is removed, too much remains in the metal at the end of the reaction to make the process valuable, and after the removal of the first slag, additions of lime and ore must be made as in ordinary working.

Improvements made in the basic process even since 1900 have rendered the application of the Monell process unnecessary in this country. Metal mixers, large vessels in which molten iron from the blast furnace is stored, were originally used mainly to obtain a more regular composition of iron for either the converter or the open-hearth process. Gradually these have developed in size from a capacity of about 70 or 80 tons up to the present day, when mixers of 200 to 600 tons capacity are used, and the metal-

mixer is now often gas-fired, so that the heat of the metal can be maintained for longer periods, and even cold pig-iron can be added. The metal mixer is now much used as a furnace for the preliminary purification of the molten cast-iron from the blast furnace. The modern metal mixers are lined with dolomite or magnesia, are gas heated, oxides of iron are added to the contents, and the blast-furnace metal made and cast into pigs during week-ends, and generally called week-end metal, can be melted in them. At the comparatively low temperature maintained in the mixers (about 1500° C.) silicon and phosphorus are partially eliminated, whilst the carbon is but little affected. The sulphur is decreased because of the length of time the metal is lying in a molten condition in the mixer, during which the manganese sulphide gradually floats to the top and is removed with the slag. The resulting metal is in good condition, and of suitable composition to be transferred to the ordinary basic open-hearth furnace and finished with a comparatively clean slag—that is, a slag not rich in phosphate.

From the results given by Mr. A. Windsor Richards in a paper to the Iron and Steel Institute recently, it would seem as if the basic Bessemer process had received, through the modification in its working designed by Dr. Massenez, an efficient tonic in its desperate struggle with the open-hearth process. By this modification the ordinary high-silicon low-sulphur Cleveland pig (c), made from native ores, is poured in a molten condition into a basic lined converter, into which has been previously placed iron ore, with a small quantity of lime. The blow is continued until the carbon flame appears and all the silicon is oxidised, when the converter is turned down and the slag is carefully removed, this slag containing 35 to 45 per cent. silica and practically no phosphate. The linings are not affected because of the short time during which this slag is acting, and also because of the comparatively low temperature. The charge is then finally blown in the ordinary way, giving a slag containing 14 to 20 per cent. of phosphoric anhydride, 95 per cent. of which is in the soluble condition. The addition of oxide distinctly improves the yield, and the process is said to be working thoroughly successfully. Week-end metal is cast into pig beds and put on the market for foundry purposes, which cannot be done with basic pig (b), as it is only suitable for conversion into steel by the basic process.

A. MCW.

NOTES.

PROF. T. G. BONNEY, F.R.S., will be the president of the British Association at the meeting to be held at Sheffield next year.

WE have to announce, with deep regret, that Dr. Arthur Gamgee, F.R.S., emeritus professor of physiology, University of Manchester, and late Fullerian professor of physiology in the Royal Institution, died in Paris on Monday, March 29, at sixty-seven years of age.

THE Anthropological Society of Paris will celebrate the jubilee of its foundation on July 7-9 next. The society was founded in 1859 by Broca.

THE annual meeting of the German Bunsen Society of Applied Physical Chemistry is to be held at Aachen on May 23-26, immediately before the International Congress of Applied Chemistry in London. Among the subjects to be discussed is the application of physical chemistry to metallurgy.